# Flavor Benchmarks

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1. The general idea(s)

2. Different approaches

3. One approach in more detail

4. Conclusions

# 1. The general idea(s)

Benchmarks: (are not a new idea . . . )

$\boxed{\text{a set of parameter points in a (your favorite) model (beyond the SM)}}$

- Tool for BSM searches at colliders (past, present, future)
  $\longrightarrow$ often it is not feasible to scan over all parameters

- Map out the characteristics of the parameter space

- Take into account all(?) possibilities

- Ensure compatibility with all(?) current bounds
  - searches for new particles
  - (low-energy) flavor bounds
  - (low-energy) electroweak precision bounds
  - cold dark matter
  - . . .

Benchmarks can be used to:

- Study the performance of different detectors
- Study the performance of different experiments
- Perform very detailed studies
- Analyzing the complementarity of different experiments
- Work out synergy effects of different experiments

Prime example from the past: SPS (Snowmass points and slopes)
(especially SPS 1a)
[*hep-ph/0202233*]

## External constraints?

If a benchmark is designed to test one sector of a specific model
$\Rightarrow$ should constraints from other sectors be taken into account?
$\Rightarrow$ could they be easily avoided?

If a benchmark is designed to test collider phenomenology

then little changes that do not affect the collider phenomenology can easily avoid:

– bounds from cold dark matter
– bounds on $(g-2)_\mu$
– $b$ physics constraints

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– precision observables constraints

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## My personal wishes:

Find/use points as described above (in the (N)MFV MSSM ) . . .

that show interesting phenomenology in low- and high-energy experiments

⇒ study the complementarity of the low/high-energy experiments

⇒ study the synergy of the low/high-energy experiments

i.e. combine results from all sources to pin down the (N)MFV MSSM

. . . but this seems to be very difficult

# 2. Different approaches

After some discussions we agreed on a two-step process:

1. Identify "interesting" points ("benchmarks") for experimental analysis at ATLAS and CMS.
   "interesting" means points in the parameter space that are "favored" by available flavor and high-energy data.

2. Provide the tools (to a master tool) so that everyone (especially the experimentalists from ATLAS and CMS) can check potentially "interesting" points (for joint (experiment + theory) analyses).

And eventually (3.):
Perform the analysis to investigate the collider reach and phenomenology in the "interesting/favored" points

## The broad idea how to proceed with the first step:

a) Identify the models we want to investigate.

b) Collect suggestions for the point(s) in each model.
(The points could also be connected to a model line, showing the variation of flavor effects.)

c) Test these points, i.e. everyone (of us) should check a point against existing experimental data.

d) Identify among the "surviving" points the ones that show the potentially most interesting phenomenology.

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Sounds good . . .
. . . reality looked a bit different

## One approach (with ATLAS):

1. Start with SPS 1a

2. Check consistency with $b$ physics observables

3. Not fully consistent? $\Rightarrow$ add (small?) flavor violation

   Fully consistent? $\Rightarrow$ add as much is allowed without violating constraints

4. $\Rightarrow$ check for new effects in high-energy analyses (ATLAS)

## Status?

Ask Luca and/or Giacomo! ;-)

## Another approach (with CMS):

1. Choose model: MFV MSSM
   later (hopefully) also NMFV MSSM

2. Find points that are in perfect agreement with $b$ physics observables

3. Check against other observables (electroweak precision, masses)

   $\Rightarrow$ build a master tool for checks
   (second step of the two-step process)

4. $\Rightarrow$ check for effects in high-energy analyses (CMS)

## Status?

See the next chapter of this talk
See the next talk by Michael Schmitt (UFL)

# 3. One approach in more detail

Step 1:

Model of our choice: MFV MSSM
possible extension at a later stage: NMFV MSSM

Starting point: hep-ph/0605012, Gino Isidori, Paride Paradisi

General feature: large $\tan\beta$, large $M_{\mathrm{SUSY}}$ $\rightarrow$ T

These points:

– pass all current $b$ physics bounds
– pass all current SUSY collider searches
– should be checked for the Higgs sector constraints
– should be checked for electroweak precision observables

$\Rightarrow$ may sound trivial, but wait for NMFV MSSM!

$\Rightarrow$ currently under study in CMS (see next talk)

## Overview about the SUSY parameters:

| | range | "best" value(s) |
|---|---|---|
| $\tan\beta$ | 30 – 50 | 40 |
| $M_A$ [GeV] | 300 – 1000 | 300, 500, 800, 1000 |
| $A_t$ [GeV] | -2000 – -1000 | -1000, -2000 |
| $\mu$ [GeV] | 500 – 1000 | 500, 1000 |
| $M_{\tilde{q}}$ [GeV] | $> 1000$ | 1000, 2000 |
| $M_{\tilde{l}}$ | 1/2 $M_{\tilde{q}}$ | |
| $M_{\tilde{g}}$ | $M_{\tilde{q}}$ | |
| $M_2$ [GeV] | | 300, 500 |
| $M_1$ | 1/2 $M_2$ | |

## Step 2: the master tool

⇒ a code that calls the special codes evaluating all observables

1. code: $b$ physics

   based on hep-ph/0605012 [*G. Isidori, P. Paradisi*]

   → used by the CMS experimentalists

2. code: Higgs and precision observables

   → FeynHiggs [*T. Hahn, S.H., W. Hollik, G. Weiglein*]

   → not yet included(?)

3. code: other/complementary observables

   → anybody interested?

⇒ Let's see how this works out . . .

# 4. Conclusions

- Benchmarks are an essential tool for collider studies

- Our idea here: study collider phenomenology in (SUSY) models:
  - agreement with direct experimental searches
  - agreement with flavor physics constraints
  - agreement with precision observables constraints

- Two step process:
  - identify such points
  - combine tools to a master tool (especially for experimentalists)

- One approach: SPS 1a (ATLAS)

- Second approach (CMS):
  - model: MFV MSSM (later: NMFV MSSM)
  - to fulfill $b$ physics: large $\tan\beta$, large $M_{\rm SUSY}$, ...
  - to check Higgs, precision observables

  $\Rightarrow$ currently under study in CMS